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ABSTRACT

This study was conducted as part of a project to develop a competency-based electrical/electronics (E/E) curriculum in Arizona. During this phase of the project, the following tasks were completed: (1) examination of selected E/E jobs in Arizona to develop a list of electronics competencies; (2) tying of electronic competencies to a particular mathematical rigor for each job; (3) definition of the mathematical rigor necessary to master the electronic competencies specified by a job definition; and (4) establishment of the framework for developing a statewide competency-based electricity/electronics technician training program. The major effort during the time-frame covered by this report was the organization of task lists and competencies. Seven major electronics areas were examined, with the key integrating factor being the relationship of applied mathematical and electronic competencies for a particular job. The theoretical concepts were organized in the following list: physics/chemical fundamentals/motor generators; electrical/circuit; combinatorial logic; timing logic; computer software; computer hardware; and assembly, inspection, instrumentation, and testing. These seven E/E organizational points, along with mathematics, provide a basis for discussion by researchers, curriculum writers, administrators, and teachers. This discussion is expected to lead to the writing of curriculum modules and the development of competency-based instructional programs designed to meet industry needs in Arizona. (KC)

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Interim Report

ELECTRONICS CURRICULUM PLANNING GUIDE FOR THE 1980'S AND 1990'S

by

Richard Bernstein, Ph.D.

and

Roger A. Mussell, Ph.D.

U.S. DEPARTMENT OF EDUCATION
NATIONAL INSTITUTE OF EDUCATION
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FOREWORD

The purpose of the Electronics Curriculum Project was to develop a conceptual framework for developing electronics curricula. Since the electronics industry, especially high technology, is such a rapidly changing field, provision must be made to accommodate change in the curriculum. Therefore, by establishing a framework, different jobs and the required competencies may be superimposed on the framework and a basis for curriculum development established.

Arizona is fortunate to have a group of electronics industry personnel who are identifying the competencies needed by several different types of electronics technicians. While this industrial group is identifying competencies, the Arizona Center for Vocational Education has been developing a framework into which the competencies may be incorporated and from which curriculum may be developed.

A major assumption during the development of the framework has been the importance of mathematics in the learning of the electronics knowledge and skills. The integration of mathematics skills with electronics skills has, therefore, become a primary task in this Electronics Curriculum Project.

This Interim Report is to serve as a discussion piece for vocational educators and electronics industry personnel. It is hoped that the identified mathematics and electronics skills will be affirmed or modified as necessary. A further intent is that the matrices will be the organizational basis for developing curriculum around the competencies identified by the electronics industry group.

Any suggestions and feedback on the material contained in this Interim Report will be appreciated. If concensus may be attained on the framework, the curriculum development will be facilitated. Please contact the Arizona Center for Vocational Education with your suggestions.

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We wish to thank the vocational educators and electronics industry personnel who reviewed draft materials. Valuable feedback was provided by those persons identified in Appendices E and F. In

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ABSTRACT

Goal and Objectives

The major goal of the Electronics Technician Curriculum Project is to improve electronics instruction in the State of Arizona. The specific objectives are to:

1. Examine selected electrical/electronic (E/E) jobs in Arizona and develop a list of electronic competencies.

2. Relate electronic competencies to a particular mathematical rigor for each job.

3. Define the mathematical rigor necessary to master the electronic competencies specified by a job definition.

4. Establish the framework for developing a statewide competency-based electricity/electronics technician training program which has built-in controls to keep it at the necessary level for the life expectency of each electronic/electrical job.

Project Overview

The major effort has been the organization of task lists and competencies. Seven major electronics areas are examined. The key integrating factor is the relationship of applied mathematical and electronic competencies for a particular job.

The theoretical concepts in electricity-electronics are organized in the following list:

1. Physics/Chemical Fundamentals/Motor Generators
2. Electrical/Circuit Concepts
3. Combinatorial Logic Concepts
4. Timing Logic Concepts
5. Computer Software Concepts
6. Computer Hardware Concepts
7. Assembly, Inspection, Instrumentation, and Testing

The seven E/E organizational points, along with mathematics, provide a basis for discussion by researchers, curriculum writers, administrators, and teachers.

Expected Outcomes

The development of task lists and competencies will lead to the writing of curriculum modules. The modules allow the development and

design of competency-based instructional programs. The programs can be designed to meet specific industry needs in Arizona.

Very clearly spelled out in this development scheme is the inter-relation and integration of applied mathematic competencies. When a particular job category is examined and the electricity-electronic competencies are related to the applied math competencies, the rigor of the training program is clearly defined. This definition in turn allows the program manager the opportunity to clearly evaluate the integration of the instructional offering. Another way to simply say it is a way to see if we are really doing what we say we are.

Jobs in the field of Electronics and related areas are in continued high demand. The competencies the students learn in technician training, assembly-type programs, and communications electronics must match the competencies required by the jobs available in industry if a high level of placement is to be maintained. In addition, programs may be evaluated for funding and ancillary support based upon labor market demand, enrollment, and placement.

The authors believe that the mathematical rigor of the E/E program will influence the number of E/E enrollments and graduates. As the mathematical rigor is increased to meet the needs of the higher technological jobs, the number of E/E enrollees/graduates will probably decrease. However, not all jobs in the electronics industry will require this mathematical rigor. A word of caution is therefore required in order not to force out students who may take jobs at the lower end of the continuum.

TABLE OF CONTENTS

	Page
FUNDING INFORMATION	ii
FOREWORD	iv
ABSTRACT	vi
INTRODUCTION	1
Chapter	
1. DESIGN OF THE STUDY	5
Labor Statistics Utilized	5
Mathematics Continuum	5
Electronics Continuum	6
Job Matrix	6
Matrix Review	6
2. RESULTS	9
Use of the Job Matrix	9
CBE Module Development	9
Electricity/Electronic Technician Matrix	10
Electrical/Electronic Assembler Matrix	10
Electronic Task List	10
Mathematics Task List	10
Specialized Skill Training	10
Program Planning: Use of Matrix	11
3. RECOMMENDATIONS	13
Dissemination	13
Next Steps	13
Appendices	
A. ELECTRONICS	15
UNIT 1: PHYSICS/CHEMICAL/FUNDAMENTALS	15
UNIT 2: ELECTRICAL/CIRCUITS CONCEPTS	17
UNIT 3: ANALOG ELECTRONICS CONCEPTS	23
UNIT 4: COMBINATORIAL LOGIC CONCEPTS	25
UNIT 5: TIMING-LOGIC CONCEPTS	26
UNIT 6: COMPUTER SOFTWARE CONCEPTS	27
UNIT 7: COMPUTER HARDWARE CONCEPTS	29
UNIT 8: ASSEMBLY, INSPECTION, INSTRUMENTATION, AND TESTING	31

TABLE OF CONTENTS (Continued)

Page

Appendices

B. MATHEMATICS COMPETENCIES TAUGHT WITHIN THE ELECTRONICS CURRICULUM 35
GENERAL MATHEMATICS 35
ALGEBRA I 35
GEOMETRY 36
ALGEBRA II 36
TRIGONOMETRY 36
ALGEBRA III 36
CALCULUS I 37
CALCULUS II 37

C. MATRIX PRESENTATION FOR JOB TRAINING COMPETENCIES: ELECTRICAL-ELECTRONIC TECHNICIAN 39
ANALOG CHART 39
DIGITAL CHART 40

D. MATRIX PRESENTATION FOR JOB TRAINING COMPETENCIES: ELECTRICAL-ELECTRONIC ASSEMBLER 41
ANALOG CHART 41
DIGITAL CHART 42

E. ELECTRONICS INSTRUCTORS REVIEWING MATRICES 43

F. INDUSTRIAL REPRESENTATIVES REVIEWING TASK LISTING . . . 45

G. SELECTED BIBLIOGRAPHY 47

H. ABOUT THE AUTHORS 49

INTRODUCTION

The Study

The study deals with competency-based education in Electrical/Electronic (E/E) areas. Three key parameters were highlighted and are used to establish a basis for E/E competency-based education (CBE). In addition, matrices were generated which relate these parameters in such a way that the level of E/E competency attained can be controlled by setting a threshold of mathematical rigor. This threshold is specified for each job analyzed in the State of Arizona.

CBE naturally leads to change in the curriculum. Job titles, job tasks, and numbers of workers become parameters which are used in the examination of this change. The job requirements in the State of Arizona must be interfaced with the requirements for CBE.

Change

Almost daily we read about technological advances and their effects on industry and workers. Electronics is one of the areas in which change and growth must be studied by vocational educators. To examine the effects in Electronics and to develop curricula accordingly, three critical factors must be examined.

1. The manner in which electronics workers are identified.
2. The separation of jobs between the services and high technology areas.
3. The level of applied mathematics taught in the Electronics Education program.

Careful examination of these factors is the key to curriculum development for the 1980's and 1990's.

In reflecting on the types of industrial workers in the United States, one envisions a manpower continuum. The classifications are:

1. Unskilled
2. Semi-Skilled
3. Skilled
4. Technician
5. Engineer
6. Scientist

This Electronics Technician Curriculum project focuses upon the workers identified as skilled and technician.

High Technology Rigor

Technological advances in the electronics industry have caused a modification to this continuum. The traditional service jobs are relatively stable, while those jobs relating to high technology are shifting, causing a break in the continuum, as shown in Figure 1. This break is due to the increased rigor required of the individual in order to be successfully employed. This increased rigor is required in the areas of applied mathematics, science, technical knowledge, and speciality skills.

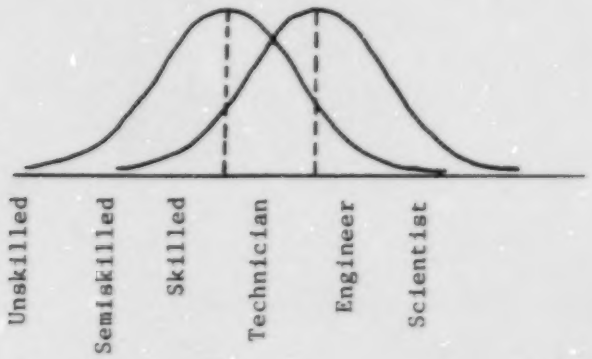


Figure 1. Workers on the Manpower Continuum

Mathematical rigor is one key factor in the analysis of jobs in the electronics industries. The applied mathematics topics taught allow for a reasonable differentiation in levels of expertise in job classifications. Therefore, mathematical rigor is one avenue that may be used to organize instructional units into a meaningful sequence.

The shift in the job continuum toward the high technology end indicates that students should learn E/E competencies at the particular threshold level. An individual with only high school math skills could only learn E/E competencies at a lower level than a community college student with college-level math skills. Competency levels are assured by setting thresholds of mathematical rigor for all E/E competencies for a particular job. The student learning under this competency threshold environment is assured of two things:

1. They will attain the job-entry skills for an E/E occupation.

2. They will attain a competency level which assures them of upward or horizontal mobility when the technology gap widens.

The program run under this mathematical rigor environment benefits in two ways:

1. Once a curriculum is set up with the right mathematical rigor for job training, teachers know they are meeting industry demands.

2. Administrators overseeing these programs are assured they are being run at the required competency level.

Competency-Based Delivery

The State of Arizona mandate for providing competency-based education (CBE) forced a modification in curriculum development and instructional methods. The modifications included proposed methods of program funding based upon labor market demand, enrollment, and placement. As a result, the authors were lead to develop a framework to analyze jobs, identify tasks, and relate mathematics with electronics instruction. In addition, the framework establishes a basis for program articulation between secondary and post-secondary institutions.

Job and Task Analysis Method

Job and task analysis methods focus upon Fryklund's (1970) original research in methods of job and activity analysis. The authors emphasize the pedagoical aspects of this analysis by interrelating the mathematics and electronics continua of duties and tasks in a matrix. This matrix format can be used to examine selected electronics jobs and to improve the process involved in development of CBE modules for the delivery of instruction.

Examination of the specific industry and student needs for training and education are a concern. The intent here is to emphasize training of the new and entry-level student, yet allow for industrial training/retraining, using the same model. The goal is to use a common language and format for the job and task analyses, thereby minimizing misunderstandings between different special interest groups.

CHAPTER 1

DESIGN OF THE STUDY

Labor Statistics Utilized

Occupational Employment and Demand figures and Bureau of Labor Statistics Occupational Titles were obtained from the Arizona Occupational Employment Forecasts for March, 1983. The specific job titles selected are:

1. Electrical and Electronic Technicians

BLS Code	DOT Code
10080803	003.161-010
	003.161-014

2. Electrical and Electronic Assemblers

BLS Code	DOT Code
61080430	726.684-018
	728.384-010
	726.261-010

3. Computer Programmers (Electronic Technician Emphasis)

BLS Code	DOT Code
10160200	007.167-018

4. Computer Operator (Electronic Technician Emphasis)

BLS Code	DOT Code
40040601	213.362-010

5. Radio Mechanic (Communication Electronics Emphasis)

BLS Code	DOT Code
50082601	823.261-018

6. TV Servicers & Repairers (Communications Electronics Emphasis)

BLS Code	DOT Code
50082602	720.281-018

These six categories reflect the majority of electronics-related jobs in Arizona which require less than a baccalaureate degree.

Mathematics Continuum

Establishment of the mathematics continuum originated from a chart in the Occupational Outlook Quarterly, Summer, 1983. This chart "How Math is Used in 100 Occupations." This format was used in the in development of the more extensive list of mathematics topics identified in this study.

It should be noted that the math topics are arranged on a continuum from simple to more complex. The major headings are: General Mathematics, Algebra I, Algebra II, Geometry, Algebra III, Trigonometry, Calculus I, and Calculus II. These topics are further broken down into subheadings. The math topics are the independent variable and remain constant throughout the utilization of the matrix.

Electronics Continuum

Analysis of the electronics jobs in terms of instructional content yields four specific areas into which tasks can be organized: analog, digital, laboratory, and specialty skills. These four classifications of tasks allow for establishment of the dependent variable on the matrix.

Job Matrix

The model for relating mathematics and electronics has been developed at William Rainey Harper College in Palatine, Illinois, by Professors K. Jauch, R. Bernstein, and R. A. Mussell. It is used to aid in curriculum development activities for skill training and technician-oriented courses that meet local industry needs.

The matrix identifies math competencies as the independent variable and then divides electronics competencies into two classifications: analog and digital, which are the dependent variable. The electronics competencies represent the core of duties and tasks found in most electronic jobs.

Tasks relating to a specific job classification, identified through industrial studies, can be incorporated into this core listing. This will clarify the teaching methodology and pedagogical concerns for CBE module development and promote articulation. For example, the Electronics Industry Task Force is a select group of persons involved in the identification of tasks for three selected electronic job categories in the microelectronics industries of Arizona. These industry professionals are in the process of identifying the generic skills and specific tasks needed in the three selected job categories. The results of this task listing can be plotted on the matrix allowing for the logical development of a meaningful curriculum in the CBE format.

Matrix Review

Review of the matrix components has been completed by two groups. The first group is composed of secondary and community college instructors of electronics. This group is identified in Appendix E. The responsibility of this group was two-fold: confirm the validity of the math and electronics tasks and support the logical sequencing of

tasks for instructional and curriculum writing purposes. Concensus indicates strong support for the matrix analysis method of electronics curriculum development.

Select industrial representatives have reviewed the listing of the electronics tasks in order to reach a concensus on the core listing of tasks. Results indicate support for the tasks identified. In some instances a reordering or expansion of task items would be appropriate. The industrial representatives are identified in Appendix F.

CHAPTER 2

RESULTS

Use of the Job Matrix

The matrix can be used to relate math skills to analog, digital, and special skill tasks. This yields a quick, realistic, and graphic way to view competencies necessary for attaining successful job entry-level skills. In addition, the matrix targets the level of math rigor necessary to teach the competency. For example, comparing the matrices for Technician and Assembler jobs, the degree of rigor in math and analog/digital skills becomes readily apparent.

Once the matrix is determined for a particular electronic job classification, there are several beneficial results:

1. The hierarchy of tasks is apparent.
2. Articulation between high schools and community college programs is more easily planned.
3. A basis for program review is provided.

The matrix clearly identifies what must be taught by job classification for entry-level skills. In addition, the matrix identifies the sequencing of CBE module presentation. Also, it is a convenient way to assist local and state administrators in the program evaluation process. Last, and perhaps most important, the local program manager and the industry trainer have a working guide to follow for the specific job analyses needed to identify specific industry skill training needs.

CBE Module Development

Overall, the matrix aids in the development of sequenced CBE material. In addition, standards of performance may be developed for various levels of learning, such as:

1. Knowledge
2. Understanding
3. Application
4. Analysis
5. Synthesis
6. Evaluation

The level of rigor is identified by the applied mathematics taught within the CBE module.

The module format follows a standard outline of:

1. Performance Objective
2. Pre-Test
3. Activities
4. Information Sheets
5. Assignment Sheets
6. Visual Aids
7. Post-Tests

Units of instruction may be planned for more than one lesson. The job and the mathematics rigor required, determine the difficulty of the learning task.

Electricity/Electronic Technician Matrix

Appendix C presents this matrix. Note the difference in rigor between analog and digital math competencies. This matrix identifies the skills and knowledge necessary to obtain an entry-level position closest to the Engineer category, as identified on the manpower continuum.

Electrical/Electronic Assembler Matrix

Appendix D presents this matrix. Note the reduced math rigor and the increased emphasis on laboratory skills and specialized skill training. This emphasis implies an equipment-intensive training program.

Electronic Task List

Appendix A shows a more detailed breakdown of analog, digital, laboratory, and specialized tasks. These listings are presented in order of simple to more complex.

Mathematics Task List

Appendix B identifies the math competencies taught in Electronics. This represents the independent variable for generation of the selected job matrix.

Specialized Skill Training

Unit 8 in Appendix A identifies assembly, inspection, instrumentation, and testing tasks. This unit merits special mention. The emphasis is on highly specialized industrial skills, which implies

intensive use of machines and test equipment in the following areas: mechanical, electrical, electronic, and fluidics. Each of the nine subheadings can be further expanded to meet industry-specific requirements, such as:

1. Shop Practices
2. Hand Tools (Use)
3. Schematic/Drawing Standards, Reading
4. Equipment Operation/Maintenance
5. Assembly/Disassembly Methods
6. Inspection/Quality Control Procedures

Other specialized skill training tasks unique to the specific job in question may be added.

Program Planning: Use of Matrix

Placing the electronic task lists in a checklist format provides the educational/industrial program or course planner a quick way to attack industrial job analysis and identify selected tasks to meet an industry need.

CHAPTER 3

RECOMMENDATIONS

Dissemination

1. Disseminate this information to electronics teachers at appropriate high schools and community colleges and to state-level managers of educational programs.

2. Disseminate this material to selected industrial representatives in the electronic job areas discussed in the study. Seek comments and feedback on the task listings.

Next Steps

1. Complete a thorough search for existing CBE materials in Arizona and other states. Assemble this data at the Northern Arizona Center for Vocational Education.

2. Continue to refine and integrate emerging industrial task lists within the matrix format. Add to the matrices where necessary.

3. Establish an education/industry task force to review, synthesize and write CBE modules for a core electronics curriculum in Arizona during the summer of 1985.

APPENDIX A - ELECTRONICS

UNIT 1: PHYSICS/CHEMICAL/FUNDAMENTALS

Duties

1. Using knowledge of Atomic Models, explain current flow, hole flow, insulators, conductors, and semiconductors.

   Task Listing
   - A. Bohr Atom
   - B. Protons/Neutrons/Electrons
   - C. Charged Particles/Like Charges Repel/Unlike Charges Attract
   - D. Electron Shells/Valence Concepts
   - E. Bonding Structures
   - F. Conductors/Insulators
   - G. Subatomic Particles

2. Define properties of materials used in electronics.

   Task Listing
   - A. Atomic Number
   - B. Density
   - C. Specific Heat
   - D. Melting Point
   - E. Thermal Properties
   - F. Conductivity
   - G. Specific Gravity
   - H. Physical Properties of Wire
     - (1) Gauge
     - (2) Resistance/1,000 Ft.
     - (3) Area in Square Inches, Circular Mills
     - (4) Safety Codes

3. Describe semiconductor physics applicable to semiconductors and microelectronics.

   Task Listing
   - A. Donors/Acceptors
   - B. Energy Levels
   - C. Minority/Majority Charge Carriers
   - D. P-N Junction Physical Properties
   - E. Junction Profiles
   - F. Hole-Electron Pairs
   - G. Doping
   - H. Diffusion Current
   - I. Leakage Currents
   - J. Depletion Regions
   - K. Avalanche Breakdown
   - L. Hall Effect

4. Analyze semiconductor fabrication and microminiature electronic manufacturing processes.

Task Listing
- A. Monolithic Integrated Circuits/Bipolar/MOS
  - (1) Crystal Growth
  - (2) Properties of SiO_2
  - (3) Etching
  - (4) Deposition
  - (5) Photoresist Methods
  - (6) Epitaxial Growth
  - (7) Diffusion
  - (8) Oxide Masking
- B. Process Control, Fabrication Environment and Safety

5. Differentiate chemical properties of batteries, capacitors, and the corrosion process of metals.

Task Listing
- A. Battery
- B. Oxidation
- C. Reforming
- D. Electrolyte Solutions
- E. Corrosion

6. Analyze mechanics of electronic components and hardware.

Task Listing
- A. Statics - Structure/Moments
- B. Dynamics

7. Analyze applications of optics in electronics.

Task Listing
- A. Spectrum
- B. Optical Sources
  - (1) Tungsten Lamps
  - (2) Florescent
  - (3) Electroluminescent Diodes
  - (4) LEDS

8. Analyze electricity and magnetism.

Task Listing
- A. Electric Fields
- B. Magnetic Fields
- C. Flux Law
- D. Faraday's Law

9. Analyze motors and generators used in electronics applications.

Task Listing
- A. AC Motors
- B. DC Motors
- C. Stepper Motors
- D. Servo Motors
- E. DC Generators
- F. AC Generators

UNIT 2: ELECTRICAL/CIRCUITS CONCEPTS

Duties

1. Interpret electrical quantities.

Task Listing
- A. Physical Basis for Volts, Ohms, Amps
- B. Conductors, Insulators, Semiconductors
- C. Periodic Chart
- D. Voltage Sources

2. Analyze and interpret wave forms commonly recognized in electronics.

Task Listing
- A. Coordinate System
- B. Time Plots
- C. Square Wave
- D. Rectangle Wave
- E. Sinusoidal Function
- F. Exponential Function

3. Identify the terminology of electric circuits.

Task Listing
- A. Symbols
- B. Branches, Junctions, Nodes
- C. Significant Electrical Quantities: Voltage, Current, Resistance, Capacitance, Inductance

4. Analyze and interpret volt-ampere graphs, resistance, and slope.

Task Listing
- A. Resistor Volt-Ampere Graph, Plot
- B. Use of Volt-Ampere Plot: Find R, Slope, Family of Characteristics

5. Analyze, interpret, and calculate Kirchoff's Voltage Law for resistors only.

Task Listing
- A. Introductory Definition
- B. Writing and Verifying Using Double Subscript Notations
- C. Writing and Verifying Using Single Subscript Notations
- D. Use of Ohms Law Relationship to Solve for Unknown Quantity (i)

6. Analyze, interpret, and calculate Kirchoff's Current Law for resistors only.

Task Listing
- A. Introductory Definition
- B. Writing and Verifying Using Double Subscript Notations
- C. Writing and Verifying Using Single Subscript Notations
- D. Use of Ohms Law Relationship to Solve for Unknown Quantity (v)

7. Explain reference direction for current.

Task Listing
- A. Single Subscript Notation
- B. Double Subscript Notation

8. Analyze, interpret, and calculate Series Circuits for resistors only.

Task Listing
- A. Description of the Circuit
- B. Current in Series Circuit: Equation and Numerical Values
- C. Voltage in Series Circuit: Equation and Numerical Values
- D. Resistance in Series Circuit: Equation and Numerical Values
- E. Power Dissipation in a Series Circuit
- F. Voltage Sources in a Series Circuit: DC, Time Varying
- G. Time Plots of Current Through Components for DC and Time Varying Sources
- H. Multiple Voltage Sources
- I. Equivalent Series Circuit
- J. Voltage Divides

9. Analyze, and interpret, and calculate Parallel and Series Parallel Circuits for resistors only.

Task Listing
- A. Description of Typical Circuits
- B. Voltage in a Parallel Circuit: 2 Branch
- C. Current in a Parallel Circuit: 2 Branch
- D. Current Divider: 2 Branch
- E. Resistance in a Parallel Circuit: 2 Branch

F. Power Dissipation in 2 Branch Circuit
G. Equivalent Parallel Circuit
H. Voltage Distribution in Series Parallel Circuits
I. Current Distribution in Series Parallel Circuits
J. Equivalent Resistance in Series Parallel Circuits
K. Current Sources
L. Loaded Voltage Divider
M. Analysis of Series Parallel Circuits Calculations of Voltage, Current, Resistance, Power, and Equivalent Resistance

10. Define Networks and Circuit Topology for electronic schematics using sources and passive components.

Task Listing
A. Description of Network Methods
B. Restatement of Importance of Nodes, Branches, Elements, Sources

11. Analyze, interpret, and calculate Node Equations for resistive circuits.

Task Listing
A. Description of Networks Applicable for Nodal Analysis
B. Development of Basic Node Equation
C. Manipulation Techniques for Setting Up Equations
D. Solution of Simultaneous Equations by Substitutions, Addition, Determinants, and Computer Methods.
E. Complete Solution of Any Circuit by Nodal Techniques Using Current and Voltage Sources (DC and AC)

12. Analyze, interpret, and calculate Loop Equations for resistive circuits.

Task Listing
A. Description of Networks Applicable for Solution by Loop Analysis
B. Writing Loop Equations
C. Simplifying Loop Equations for Solution by Algebra, Determinants, and Computer Methods
D. Complete Solutions of Multiloop Circuits by Loop Techniques When Current and Voltage Sources are Utilized (DC and AC)

13. Analyze, interpret, and calculate Network Theorems applied to resistive circuits.

Task Listing
A. Description of Variety of Theorems Available and Typical Applications
B. Superposition Theorem
C. Thevenin's Theorem
D. Norton's Theorem

E. Node Splitting
F. Millman's Theorem

14. Define sine wave, amplitude, frequency, and phase as applied to resistive-capacitive (RC) and resistive-inductive (RL) circuits.

15. Analyze, interpret, and calculate RC and RL circuits using phasor representation.

Task Listing
A. Rectangular Form
B. Polar Form
C. Exponential Form
D. Transformations
E. Arithmetic Operations

16. Calculate Reactance in RC and RL circuits.

Task Listing
A. Capacitive
B. Inductive

17. Calculate Impedance in RC and RL circuits.

Task Listing
A. Series
B. Parallel
C. Ladder
D. Bridge Network

18. Analyze, interpret, and calculate Alternating Current Circuit Laws.

Task Listing
A. KVL-KCL in Time Domain: Sine Wave
B. KVL-KCL in Phasor Representation
C. Transformation Between Forms
D. Network Theorems
   (1) Thevenin
   (2) Norton
E. Voltage Dividers: Capacitive, Inductive, and Resistive
F. Current Dividers: Capacitive, Inductive, and Resistive

19. Define and calculate Admittance.

Task Listing
A. Conductance
B. Susceptance
C. Transformation Between Admittance and Impedance

20. Analyze, interpret, and calculate equivalent series-parallel circuits, examine, duality.

Task Listing
- A. Series to Parallel
- B. Parallel to Series
- C. Applications

21. Describe and calculate Bode Plot applications to RC and RL circuits.

Task Listing
- A. Definition of Decible
- B. Log Plots
- C. Semi-Log Plots
- D. Roll Off
- E. Break Frequency
- F. Low/High Pass Filters
- G. Bandpass Filters

22. Analyze, interpret, and calculate power as used in RC and RL circuits.

Task Listing
- A. Rate of Change of Energy Per Unit Time
- B. Joules/Sec = Watts Definitions
- C. Real Power - Watts
- D. Imaginary Power - VARS
- E. Complex Power - Volt-Amperes
- F. Power Triangle
- G. Power Factor

23. Analyze, interpret, and calculate three-phase electrical circuit systems.

Task Listing
- A. Line-to-Line Phasor Voltage and Current
- B. Line-to-Neutral Phasor Voltage and Current
- C. Wye and Star/Delta Circuits and Transformations

24. Analyze, interpret, and calculate transient response in RC and RL circuits.

Task Listing
- A. Exponential Function
- B. Charge/Discharge Curves
- C. Time Constant
- D. Initial Conditions
- E. Inductive Circuit, $I_L(t=0^-) = I_L(t=0^+)$
- F. Capacitive Circuits, $V_C(t=0^-) = V_C(t=0^+)$

25. Analyze, interpret, and calculate resonant circuit characteristics for RLC circuits.

Task Listing

A. Definition of Resonance
B. Series Resonance
C. Parallel Resonance
D. Filters
E. Influence of Q on Bandwidth

26. Analyze, interpret, and calculate power matching applications in RLC circuits.

Task Listing

A. Definition of Conjugate Matching
B. Bandwidth, Resonant Frequency, Matching Interrelation
C. Matching Circuits
   (1) L Network
   (2) T Network
   (3) Pi Network

27. Analyze, interpret, and calculate characteristics of tapped resonant circuits.

28. Analyze, interpret, and calculate characteristics of coupled resonant circuits.

29. Analyze, interpret, and calculate transients in RLC circuits.

Task Listing

A. Definition of Ringing
B. Measurement
C. Reduction Techniques

30. Analyze, interpret, and calculate transmission line characteristics.

Task Listing

A. Lumped System vs. Distributed System
B. Instantaneous Voltages and Currents
C. Propagation Delay
D. Traveling Waves
E. Phasor Addition of Traveling Waves
F. Exponential Amplitude Decay of Traveling Waves
G. Standing Waves and Standing Wave Ratio (SWR)
H. Reflected and Transmitted Power
I. Power Matching of Transmission Lines
J. Smith Chart Calculations

31. Analyze, interpret, and calculate Antenna characteristics.

Task Listing
- A. Radiation Pattern
- B. Radiated Polarization
- C. Beam Width/Antenna Dimension/Wavelength Tradeoff
- D. Matching SWR/Resonance
- E. Antenna Arrays

UNIT 3: ANALOG ELECTRONICS CONCEPTS

Duties

1. Describe passive components and active devices.

Task Listing
- A. Passive Devices Resistor, Capacitor, Inductor
- B. Active Devices Diodes, Transistor, FET, Power Devices

2. Demonstrate the use of power sources.

Task Listing
- A. DC
- B. AC
- C. Voltage/Current Sources

3. Analyze, interpret, and calculate the DC Biasing techniques applied to electronic semiconductor devices.

Task Listing
- A. Specifications
- B. Volt-Ampere Characteristics
- C. Test Circuit
- D. Quiescent Conditions and Device/Circuit Interrelation
- E. DC Biasing Stability
  - (1) Testing
  - (2) Analysis of Stability vs. Circuit/Device Parameter Changes
- F. The DC Biasing Topic is Applied to:
  - (1) Diodes
  - (2) Transistors
  - (3) Tubes
  - (4) FET
  - (5) Semiconductor Power Devices such as SCR, Triac, Diac
  - (6) Integrated Circuits
  - (7) Optoelectronic Devices

4. Interpret and calculate amplifier fundamental characteristics.

Task Listing
- A. Amplification/Gain Definitions
  - (1) Voltage Gain
  - (2) Current Gain
  - (3) Power Gain
- B. Variation of Gain vs. Device/Circuit Parameter Changes
- C. Amplification vs. Signal Swing: This topic is done for each relevant device:
  - (1) Transistor CE, CB, CC
  - (2) FET CG, CS, CD
  - (3) Op Amp
  - (4) Tube

5. Interpret advanced amplifier concepts.

Task Listing
- A. AC Gain and Relation to Slope
- B. Nonlinear Operation and DC Biasing
- C. Input/Output Impedance of Amplifiers
- D. Influence of Source Impedance
- E. Amplifier Classification - A, B, C
- F. Interconnection of Amplifier Stages

6. Analyze, interpret, and calculate power amplifier characteristics.

Task Listing
- A. Efficiency vs. Amplifier Classification
- B. Heat Sink Calculations/Environmental Impact
  - (1) Thermal Resistance
  - (2) Heat Flow

7. Describe amplifier oscillation characteristics and establish bias criteria for oscillation.

Task Listing
- A. Oscillation Criteria
- B. Feedback
- C. Oscillator Configuration
- D. Amplifier Stability
- E. Compensation of Feedback Systems

8. Interpret operation and use of basic electronic circuits.

Task Listing
- A. Rectifiers
- B. Power Supply Regulation
- C. Low Pass Amplifier
- D. Bandpass Amplifiers
- E. Oscillators
- F. Power Amplifiers

UNIT 4: COMBINATORIAL LOGIC CONCEPTS

Duties

1. Explain binary math as applied in digital electronics.

   Task Listing
   - A. Counting
   - B. Number Representation
   - C. Bits/Counting Span

2. Interpret use of truth table.

   Task Listing
   - A. Number of Rows vs. Bits
   - B. Relation to Logic

3. Describe logic definitions and equivalence techniques in digital electronics.

   Task Listing
   - A. And
   - B. Inclusive OR
   - C. Exclusive OR
   - D. NAND
   - E. NOR
   - F. Relation to Truth Table

4. Tell what a Ladder Diagram is and explain the sequencing of digital Operations.

   Task Listing
   - A. Definition of Relay Logic Operations
   - B. Relation of Logic Definitions to Relay Logic
   - C. Logic Sequence Operation of the Ladder

5. Explain logic functions via gate, output, input, block diagram, and truth tables.

   Task Listing
   - A. Logic Gate Representations
   - B. Output vs. Input Logic Levels
   - C. Block Diagram Fundamentals
   - D. Relation to Truth Tables

6. Interpret code conversions.

   Task Listing
   - A. Binary to BCD
   - B. Binary to Gray Code

7. Analyze applications of DeMorgan's Laws to circuit minimization techniques.

Task Listing
- A. AND Equivalent to a NOR
- B. OR Equivalent to a NAND

8. Utilize boolean algebra in applications of digital logic.

Task Listing
- A. Oring, Anding, Exclusive Oring notations.
- B. Product of Sums/Sums of Products
- C. Boolean Algebra Laws of Complementation, Computation, Distribution, etc.
- D. Applications to DeMorgan's Laws

9. Apply minimization techniques to digital circuits.

Task Listing
- A. Boolean Algebra Manipulation
- B. Karnaugh Mapping
- C. Don't Care Conditions

10. Investigate applications of combinatorial logic to digital circuits.

Task Listing
- A. Analyze Logic Block Diagrams
- B. Input/Output Logic Gate Representation Dependence
- C. Design Logic from Truth Tables
- D. Design Logic Gate Representation from Boolean Functions

UNIT 5: TIMING-LOGIC CONCEPTS

Duties

1. Perform combinatorial logic operations as required.

2. Analyze Flip-Flops/Bistable multivibrators.

Task Listing
- A. Cross-Coupled NANDS/NOR
- B. R/S Flip Flops (FFS)
- C. Triggered (FFS)
- D. D-Type FFS
- E. J-K Master/Slave FFS/Registers

3. Describe a "One Shot" multivibrator.

4. Analyze Schmitt Trigger circuits.

5. Analyze, interpret, and build simple counters.

   Task Listing
   - A. Ripple Counters
   - B. Shift Registers
   - C. Synchronous Counters

6. Analyze, interpret, and build counters with feedback-analysis.

   Task Listing
   - A. Shift Counters
     - (1) Ring
     - (2) Johnson
   - B. Truncated Counters
   - C. Missing State Counters - Irregular Count Sequences

7. Analyze, interpret, and describe multiplexing techniques applied to digital electronics.

8. Analyze and interpret State Transition Diagrams (STD).

   Task Listing
   - A. Timing Diagrams to a STD
   - B. STD to a Timing Diagram

9. Interpret the synthesis of the digital machine.

   Task Listing
   - A. Moore Machine Synthesis
   - B. Mealey Machine Synthesis

10. Analyze timing and clock design techniques.

UNIT 6: COMPUTER SOFTWARE CONCEPTS

Duties

1. Analyze and program a dedicated microprocessor for introductory control applications.

   Task Listing
   - A. Number Systems/Arithmetic
     - (1) Decimal
     - (2) Binary
     - (3) Octal
     - (4) Hexadecimal

B. Binary Numbers/Arithmetic
   (1) Unsigned
   (2) Signed/2's Complement
C. Computer Model
   (1) Central Processing Unit (CPU)
   (2) Memory
   (3) Input/Output (I/O)
D. Addressing Structure
   (1) Addresses = 2^n
   (2) Addressing Modes
      (a) Direct
      (b) Indirect
      (c) Indexed
      (d) Inherent
      (e) Relative
   (3) Basic Definition of ROM/RAM
   (4) Memory Map
E. Definition of a Program
   (1) Binary Numbers represent commands
   (2) Commands are instructions which are store in memory
   (3) Computer fetches each command and executes
   (4) Computer recognizes data is an instruction when in fetch mode (Von Neuman Machine)
F. Program Model vs. Hardware Model
   (1) Program Model only relevant for assembly language
   (2) High-Level Language is transparent to program model
   (3) Memory Map is relevant to assembly language only.
G. Program Decisions
   (1) Implemented by having a place in CPU hold status (Status Register)
   (2) Status Register has several bits which are set or reset according to CPU condition
   (3) Using the status bits, a program can jump out of a straight line programming sequence
H. Program Looping
   (1) Decisions can be used to allow sections of programs to be reused
   (2) Computer process is fast enough to loop back again and again to obtain a certain condition
   (3) Looping allows conditions to be met which are set up by the programmer
I. Basic Assembly Language Programs
   (1) Clear a section of memory
   (2) Move a section of memory
   (3) Test a section of memory
   (4) Basic data manipulation involving logic and arithmetic operations
   (5) Ability to make decisions based on individual and group values of bits

2. Demonstrate advanced software programming techniques applied to the dedicated microprocessor.

Task Listing

A. Computer Number Characteristics
   (1) Fixed Point Numbers
   (2) Floating Point Numbers
   (3) Multiple Precision
B. Floating Point Routines
   (1) Normalization
   (2) Addition/Subtraction
   (3) Multiplication/Division
   (4) Rounding/Truncating
   (5) Input/Output
C. Implementation of Formula Solving
   (1) Store Equation in Machine
   (2) Put Independent Variable into Equation
   (3) Produce Dependent Variable from Program
   (4) Used in A/D Conversions
   (5) Scaling of Transducers
D. Decisions
   (1) Signed Decisions
   (2) Closed/Open Interval Decisions
   (3) BCD Arithmetic Decisions
E. Microprocessor Monitor Programs
   (1) Cold Start
   (2) Warm Start
   (3) Initialization
   (4) General Processor Control
F. Multitasking (Control)
   (1) Interrupt Driven
   (2) Task Priority
   (3) Timed Task Routine
   (4) Timed Task Interrupts
G. Software Control of Support Chips
   (1) Serial Interface Adapter
   (2) Parallel Interface Adapters
   (3) Video Display Chip
   (4) Interfacing to Video Display Terminals, Keyboards, and Printers

UNIT 7: COMPUTER HARDWARE CONCEPTS

Duties

1. Analyze and interpret microprocessor program hardware requirements.

Task Listing

A. Stored Program Machine
   (1) Variable Task Sequences
   (2) Must Have Memory Available for Instruction

(3) Wired-Program Machine Does Only Simple or Fixed Series of Tasks

B. Basic Computer Elements
   (1) Central Processing Unit (CPU)
   (2) Memory
   (3) Input/Output (I/O)

C. CPU Instruction Handling
   (1) Instruction Decode and Control
   (2) Instruction Register
   (3) Fetch Cycle

D. CPU Arithmetic Logic Unit (ALU)
   (1) Accumulator Operation/Single-Multiple
   (2) Status Register
   (3) Scratch Pad Register

E. CPU Registers
   (1) Program Counter
   (2) Stack Pointer
   (3) General-Purpose Registers

F. CPU Timing and Control
   (1) Clock Signals
   (2) Read/Write (R/W)
   (3) Fetch-Execute Cycle
   (4) Memory Fetch
   (5) Interrupt/Halt

G. CPU Address/Data Lines
   (1) Memory Capacity
   (2) Single Precision Data

H. Semiconductor Memories
   (1) ROM
   (2) RAM
   (3) PROM
   (4) EPROM

I. Bulk Storage Memory
   (1) Disks
   (2) Tape
   (3) Paper

J. Semiconductor Memory Characteristics
   (1) Static Memory
   (2) Access Time

K. Input/Output
   (1) Memory Mapped I/O
   (2) CPU I/O Control
   (3) Devices (Printer, Keyboard, etc.)
   (4) Bus Structures (e.g. RS232)

2. Interpret advanced computer architecture, memory, input/output, and networking considerations.

Task Listing

A. CPU Architecture Types
   (1) Stack-Oriented Machine
   (2) Register-Oriented Machine

(3) Memory-Oriented Machine

B. (CPU/Memory) Timing and Control
   (1) Memory Timing Constraints
   (2) CPU Timing Constraints
   (3) Matching Memory to CPU/Static RAM
   (4) Matching Memory to CPU/Dynamic RAM
      (a) RAS Signals
      (b) CAS Signals
      (c) Clock Relations
   (5) Memory Multiplexing

C. Memory Map Layout
   (1) Chip Enables
   (2) Addressing Decoding
   (3) Redundant/Nonredundant Memory Access

D. Input/Output Consideration
   (1) Serial
   (2) Parallel
   (3) Tri-state Buffers
   (4) Bus Selection
   (5) Memory Mapped I/O Device PIA, ACIA
   (6) UARTs

E. Networks
   (1) Arbitration
   (2) Protocols
   (3) Linking

UNIT 8: ASSEMBLY, INSPECTION, INSTRUMENTATION, AND TESTING

Duties

1. Interpret, calculate, and formulate mechanical assembly processes.

   Task Listing
   A. Safety and Shop Practices
   B. Hand Tools, Use of
   C. Reading of Mechanical and Electronic Drawings
   D. Common Shop Equipment Operation
   E. Assembly Processes

2. Interpret, calculate, and formulate electronic assembly processes.

   Task Listing
   A. Safety and Shop Practices
   B. Hand Tools, Use of
   C. Reading of Electronic Schematics and Mechanical Drawings
   D. Common Shop Equipment Operation
   E. Hand Assembly Methods
   F. Automatic Assembly Methods

G. Printed Circuit Board Layout and Manufacturing Techniques
   (1) Manual Fabrication
   (2) Automated Fabrication
      (a) Computer-Aided Design
      (b) Photoplot
      (c) Etching Process
      (d) Numerical Control Drilling
      (e) Automatic Parts Insertation
      (f) Automated Soldering Methods
H. Cabling Techniques
   (1) Harness Boards
   (2) Wiring Methods
   (3) Termination Techniques
   (4) Bundling/Tyeing Techniques
   (5) Labeling Wire and Breakouts
   (6) Wire Wrapping

3. Interpret, calculate, and formulate microelectronic assembly processes.

Task Listing
A. Safety and Shop Practices
B. Hand Tools, Use of
C. Common Shop Equipment Operation
D. Microelectronic Assembly Processes
E. Inspection and Quality Control Methods
F. Testing Techniques

4. Interpret, calculate, and formulate mechanical inspection processes.

Task Listing
A. Safety and Shop Practices
B. Use of Hand Tools, Gauges, Shop Standards
C. Reading of Mechanical Drawings
D. Understanding of Tolerances
E. Common Shop Equipment Operation
F. Automatic Inspection Methods
   (1) Visual
   (2) Mechanical
G. Fabrication Standards
H. Quality Control Practices

5. Interpret, calculate, and formulate electrical inspection processes.

Task Listing
A. Safety and Shop Practices
B. Hand Tools, Use of
C. Reading Electrical Schematics
D. Components
E. Printed Circuit Boards (PCB)

F. PCB Assemblies
G. Common Shop Equipment Operation
H. Automatic Inspection Methods
   (1) Mechanical
   (2) Visual
I. Fabrication Standards
J. Quality Control Practices

6. Interpret, calculate, and formulate printed circuit board fabrication processes.

Task Listing

A. Photoreduction
B. Film Preparation
C. Drilling
D. Printed Circuit Plating
E. Soldering
F. Inspection
G. Quality Control
H. Chemistry of Plating
I. Chemistry of Etching
J. Design and Fabrication Standards
K. Processes Associated with Design Fabrication Standards, Circuits, and the Control of These Processes

7. Show proper operating procedures for electrical instrumentation at the first level of difficulty.

Task Listing

A. Volt-Ohm-Millimeter (VCM), Digital Multimeter
   (1) Read AC, DC Volts, DC Current, Ohms
   (2) Basic Measuring Principles of Volts and Amps
   (3) Unit does not measure AC current
B. Function Generator
   (1) Set Frequency, Function, and Amplitude
   (2) Knowledge of Minimum, Maximum Frequency, and Amplitude Limitations
C. Oscilloscope
   (1) Measure Amplitude and Time, Determine Frequency
   (2) Beginning Knowledge of Triggering
   (3) Multitrace Usage
D. DC Power Supply
   (1) Limitations of Voltage and Current
   (2) Regulation

8. Intepret operating characteristics for electrical instrumentation at the second level of difficulty.

Task Listing

A. VOM
   (1) All of Level 1
   (2) Frequency Limitations

(3) Application of Ohms Per Volt and Meter Restrictions

B. Function Generator
   (1) All of Level 1
   (2) Frequency and Amplitude Limitations
   (3) Influence and Effects of Input and Output Impedance

C. Oscilloscope
   (1) All of Level 1
   (2) External Triggering
   (3) Measurement of Phase Shift
   (4) Delayed Sweep Operation
   (5) Influence of Probe and Input Impedance on Measurements
   (6) Use of Current Probe

D. Sweep Generator
   (1) All of Level 1
   (2) Interaction of Sweep Generator with Oscilloscope
   (3) Markers

9. Interpret and utilize special electronic test equipment.

Task Listing

A. Curve Tracer
B. Logic Analyzer
C. R-L-C Bridge
D. High-Speed Oscilloscope
E. Impedance Meters
F. Frequency Counters

APPENDIX B

MATHEMATICS COMPETENCIES TAUGHT
WITHIN THE ELECTRONICS CURRICULUM

GENERAL MATHEMATICS

1. Number Representation
   - A. Whole Numbers
   - B. Fractions
   - C. Decimals
   - D. Scientific Notation

2. Simple Applications
   - A. Estimation
   - B. Quick Computation
   - C. Rounding
   - D. Averaging
   - E. Percent

3. Elementary Operations/Calculators
   - A. Square Root
   - B. Fxponents
   - C. Ratio/Proportion
   - D. Use of Calculators

4. Elementary Geometric Concepts/Calculators
   - A. Angle Measurement
   - B. Area, Perimeter
   - C. Volume
   - D. Pythagorean Theorem

5. Statistics and Probability
   - A. Statistical Parameters
     1. Average
     2. Mode
     3. Deviation
   - B. Statistical Graphing
   - C. Probability

6. Metrics: Units Constants and Conversion Factors

ALGEBRA I

1. Linear Equations
2. Linear Inequalities
3. Formulas
4. Polynomials (Operations)
5. Factoring Polynomials
6. Rational Expressions

7. Coordinate Graphing
8. Systems of Equations
9. Simplifying Radicals
10. Quadratic Equations

GEOMETRY

1. Induction, Deduction, Logic
2. Angles/Perpendiculars
3. Parallel Lines/Planes
4. Congruent Triangles
5. Similar Polygons
6. Circles
7. Constructions/Loci
8. Distance in Plane
9. Transformations

ALGEBRA II

1. Linear/Quadratic Functions
2. Complex Numbers
3. 2nd Degree Equations/2 Variable
4. Systems in 3 Variables
5. Exponent/Logarithms

TRIGONOMETRY

1. Trigonometric Functions
2. Trigonometric Identities
3. Trigonometric Equation
4. Trigonometric Function/Indentities with Time Dependence

ALGEBRA III

1. Polynomials
2. Sequence/Series
3. Permitations/Combinations
4. Vectors
5. Matrices/Determinants
6. Coordinate Transformations
7. Conic Sections
8. Synthesis of Functions

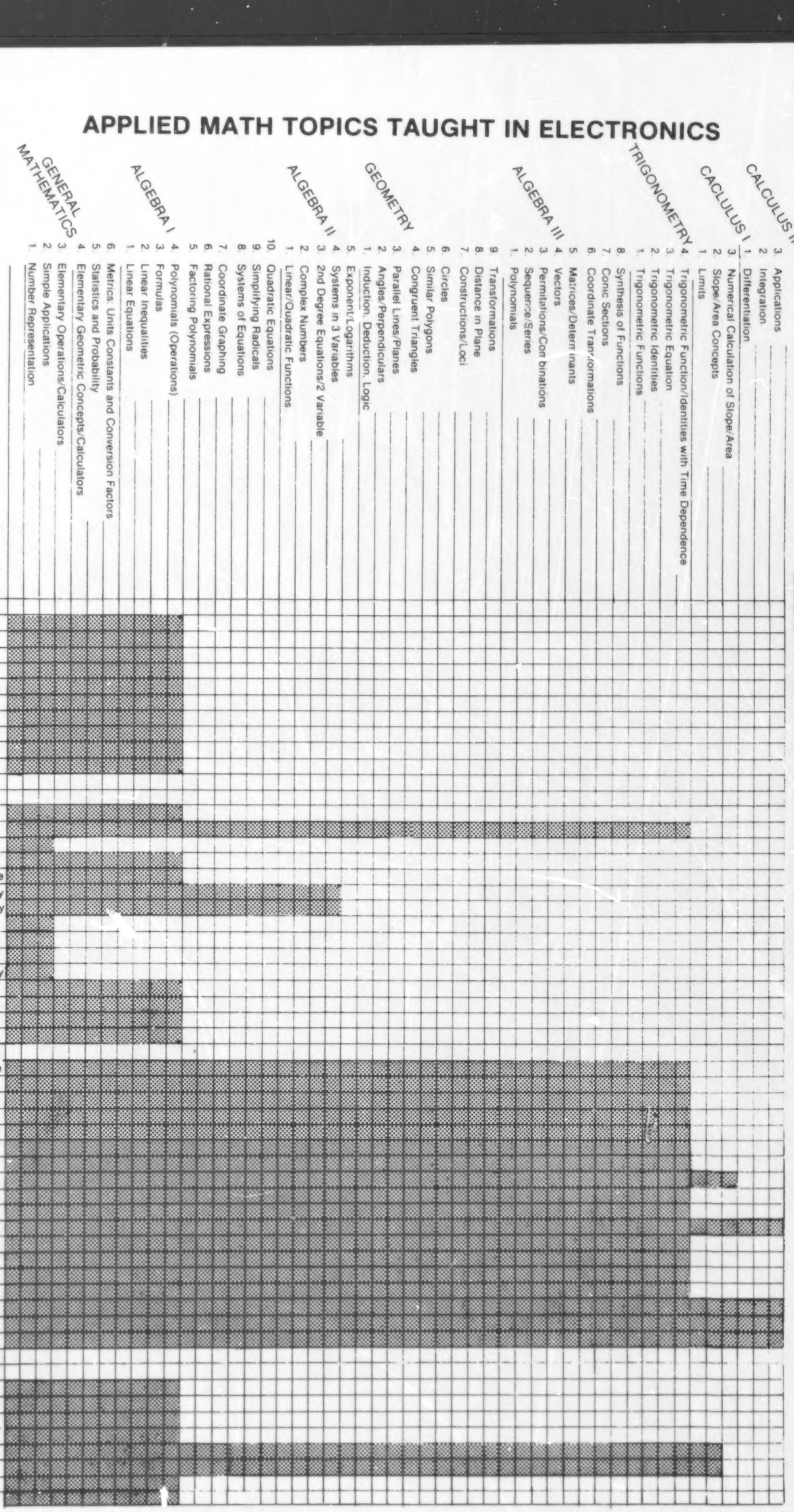
CALCULUS I

1. Limits
2. Slope/Area Concepts
3. Numerical Calculation of Slope/Area

CALCULUS II

1. Differentiation
2. Integration
3. Applications

APPLIED MATH TOPICS TAUGHT IN ELECTRONICS



ANALOG TASKS

PHYSICS/CHEMICALS/ FUNDAMENTALS
1. Atomic Models
2. Properties of Materials
3. Semiconductor Physics
4. Semiconductor Fabrication/ Microminiature Electronics
5. Chemical Properties
6. Mechanics
7. Optics
8. Electricity and Magnetism
9. Motors and Generators

ELECTRICAL/CIRCUITS CONCEPTS
1. Electrical Quantities
2. Wave Forms
3. Terminology of Electric Circuits
4. Volt-Ampere Graphs, Resistance, and Slope
5. Kirchoff's Voltage Law, Resistors Only
6. Kirchoff's Current Law, Resistors Only
7. Reference Direction for Current
8. Series Circuit, Resistors Only
9. Parallel and Series-Parallel Circuits, Resistors Only
10. Networks and Circuit Topology
11. Node Equations, Resistors Only
12. Loop Equations, Resistors Only
13. Network Theorems, Resistors
14. Sine Wave Amplitude, Frequency and Phase
15. Phasor Representation
16. Reactance
17. Impedance
18. AC Circuit Laws
19. Admittance
20. Equivalent Series/Parallel Circuits
21. Bode Plot
22. Power
23. Three-Phase Systems
24. Transients (RC, RL) Circuits
25. Resonant Circuits
26. Power Matching
27. Tapped Resonant Circuits
28. Coupled Resonant Circuits
29. Transients in RLC Circuits
30. Transmission Lines
31. Antennas

ANALOG ELECTRONICS CONCEPTS
1. Components
2. Power Sources
3. DC Biasing
4. Amplifier Fundamentals
5. Advanced Amplifier Concepts
6. Power Amplifier Concepts
7. Oscillation
8. Basic Circuit Familiarization

ELECTRICAL/ELECTRONIC TECHNICIAN

APPLIED MATH TOPICS TAUGHT IN ELECTRONICS

CALCULUS II
3. Applications
2. Integration

CALCULUS I
1. Differentiation
3. Numerical Calculation of Slope/Area
2. Slope/Area Concepts
1. Limits

TRIGONOMETRY
4. Trigonometric Function/Indentities with Time Dependence
3. Trigonometric Equation
2. Trigonometric Identities
1. Trigonometric Functions

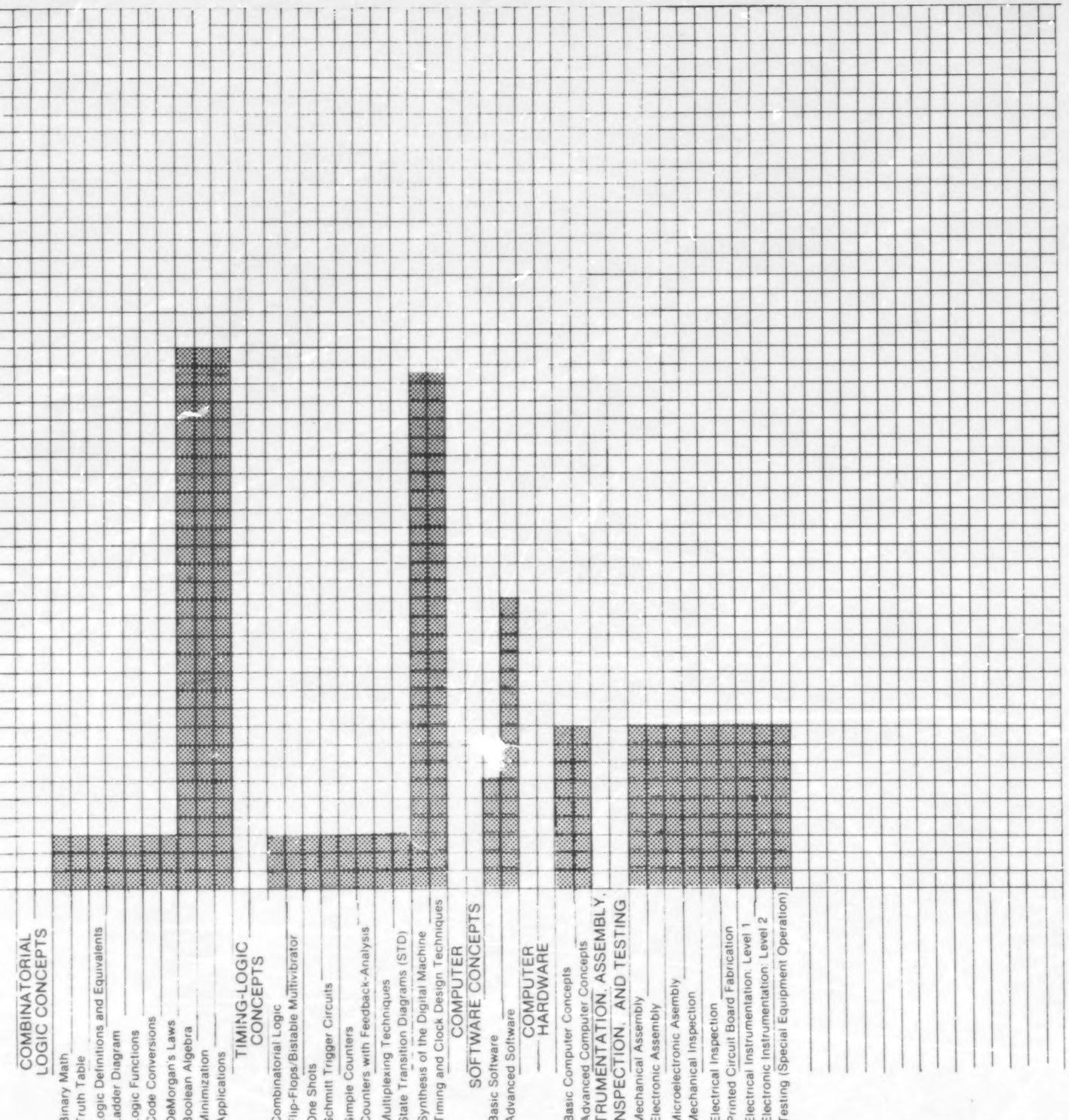
ALGEBRA III
8. Synthesis of Functions
7. Conic Sections
6. Coordinate Transformations
5. Matrices/Determinants
4. Vectors
3. Permutations/Combinations
2. Sequence/Series
1. Polynomials

GEOMETRY
9. Transformations
8. Distance in Plane
7. Constructions/Loci
6. Circles
5. Similar Polygons
4. Congruent Triangles
3. Parallel Lines/Planes
2. Angles/Perpendiculars
1. Induction, Deduction, Logic

ALGEBRA II
5. Exponent/Logarithms
4. Systems in 3 Variables
3. 2nd Degree Equations/2 Variable
2. Complex Numbers
1. Linear/Quadratic Functions

ALGEBRA I
10. Quadratic Equations
9. Simplifying Radicals
8. Systems of Equations
7. Coordinate Graphing
6. Rational Expressions
5. Factoring Polynomials
4. Polynomials (Operations)
3. Formulas
2. Linear Inequalities
1. Linear Equations

GENERAL MATHEMATICS
6. Metrics: Units Constants and Conversion Factors
5. Statistics and Probability
4. Elementary Geometric Concepts/Calculators
3. Elementary Operations/Calculators
2. Simple Applications
1. Number Representation



DIGITAL TASKS

COMBINATORIAL LOGIC CONCEPTS
1. Binary Math
2. Truth Table
3. Logic Definitions and Equivalents
4. Ladder Diagram
5. Logic Functions
6. Code Conversions
7. DeMorgan's Laws
8. Boolean Algebra
9. Minimization
10. Applications

TIMING-LOGIC CONCEPTS
1. Combinatorial Logic
2. Flip-Flops/Bistable Multivibrator
3. One Shots
4. Schmitt Trigger Circuits
5. Simple Counters
6. Counters with Feedback-Analysis
7. Multiplexing Techniques
8. State Transition Diagrams (STD)
9. Synthesis of the Digital Machine
10. Timing and Clock Design Techniques

COMPUTER SOFTWARE CONCEPTS
1. Basic Software
2. Advanced Software

COMPUTER HARDWARE
1. Basic Computer Concepts
2. Advanced Computer Concepts

INSTRUMENTATION, ASSEMBLY, INSPECTION, AND TESTING
1. Mechanical Assembly
2. Electronic Assembly
3. Microelectronic Asembly
4. Mechanical Inspection
5. Electrical Inspection
6. Printed Circuit Board Fabrication
7. Electrical Instrumentation: Level 1
8. Electronic Instrumentation: Level 2
9. Testing (Special Equipment Operation)

ELECTRICAL—ELECTRONIC ASSEMBLER

APPLIED MATH TOPICS TAUGHT IN ELECTRONICS

CACULUS II
3. Applications
2. Integration
1. Differentiation

CALCULUS I
3. Numerical Calculation of Slope/Area
2. Slope/Area Concepts
1. Limits

TRIGONOMETRY
4. Trigonometric Function/Indentites with Time Dependence
3. Trigonometric Equation
2. Trigonometric Identities
1. Trigonometric Functions

ALGEBRA III
8. Synthesis of Functions
7. Conic Sections
6. Coordinate Transformation
5. Matrices/Determinants
4. Vectors
3. Permitations/Combinations
2. Sequence/Series
1. Polynomials

GEOMETRY
9. Transformations
8. Distance in Plane
7. Construction/Loci
6. Circles
5. Similar Polygons
4. Congruent Triangles
3. Parallel Lines/Planes
2. Angles/Perpendiculars
1. Induction, Deduction, Logic

ALGEBRA II
5. Exponent/Logarithms
4. Systems in 3 Variables
3. 2nd Degree Equations/2 Variables
2. Complex Numbers
1. Linear/Quadratic Functions

ALGEBRA I
10. Quadratic Equations
9. Simplifying Radicals
8. Systems of Equations
7. Coordinate Graphing
6. Rational Expressions
5. Factoring Polynomials
4. Polynomials (Operations)
3. Formulas
2. Linear Inequalities
1. Linear Equations

GENERAL MATHEMATICS
6. Metrics: Units Constants and Conversion Factors
5. Statistics and Probability
4. Elemenary Geometric Concepts/Calculators
3 Elementary Operations/Calculators
2. Simple Applications
1. Number Representation

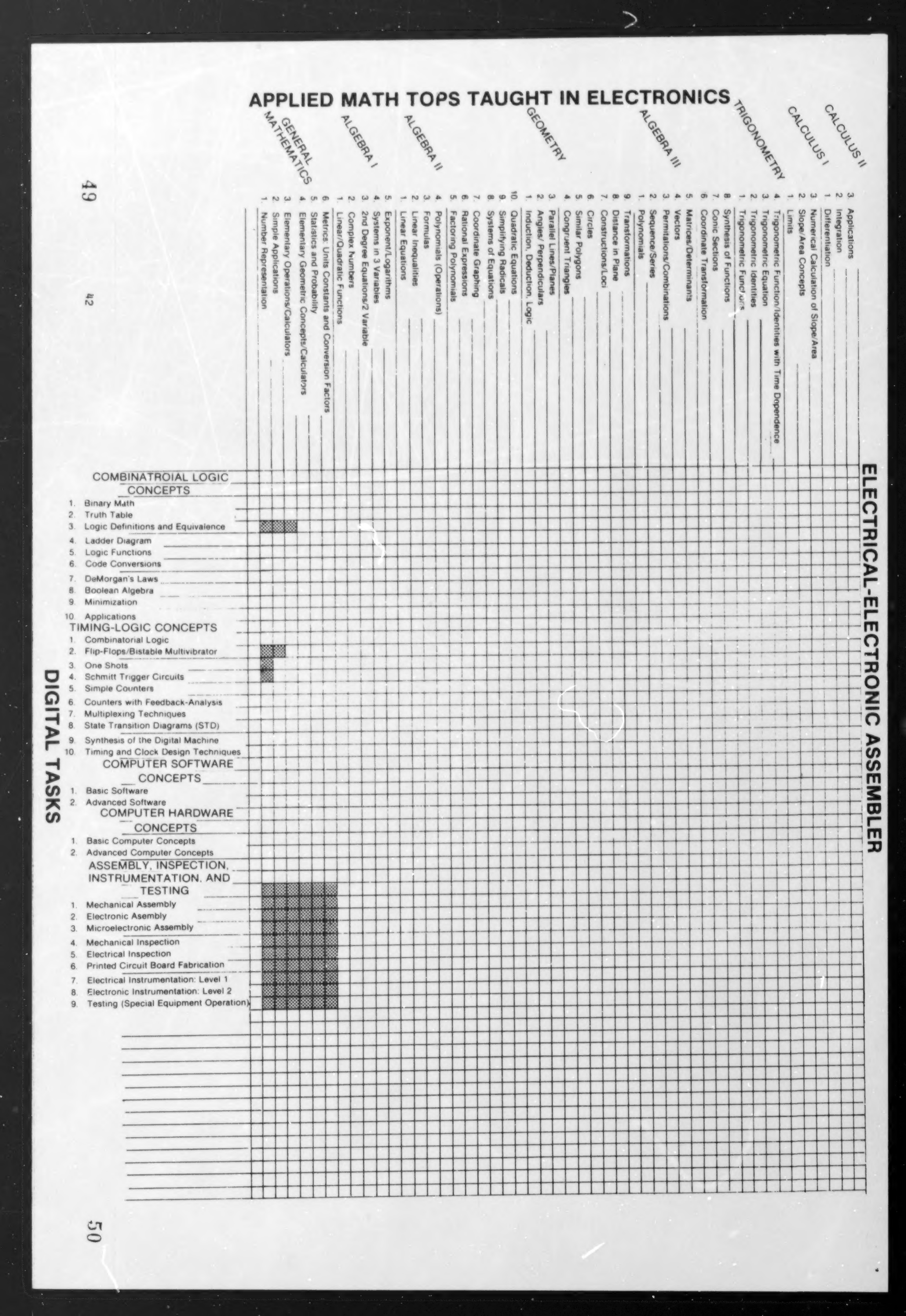
ANALOG TASKS

PHYSICS/CHEMICAL/ FUNDAMENTALS
1. Atomic Models
2. Properties of Materials
3. Seminconductor Physics
4. Semiconductor Fabrication/ Microminiature Electronics
5. Chemical Properties
6. Mechanics
7. Optics
8. Electricity and Magnetism
9. Motors and Generators

ELECTRICAL/CIRCUITS CONCEPTS
1. Electrical Quantities
2. Wave Forms
3. Terminology of Electric Circuits
4. Volt-Ampere Graphs, Resistance, and Slope
5. Kirchoff's Voltage Law, Resistors Only
6. kirchoff's Current Law, Resistors Only
7. Reference Direction for Current
8. Series Circuit, Resistors Only
9. Parallel and Series Parallel Circuits, Resistors Only
10. Networks and Circuit Topology
11. Node Equations, Resistors Only
12. Loop Equations, Resistors Only
13. Network Theorems, Resistors
1. Sine Wave Amplitude, Frequency and Phase
15. Phasor Representation
16. Reactance
17. Impedance
18. AC Circuit Laws
19. Admittance
20. Equivalent Series/Parallel Circuits
21. Bode Plot
22. Power
23. Three-Phase Systems
24. Node Equations, Resistors Only
25. Resonant Circuits
26. Power Matching
27. Tapped Resonant Circuits
28. Coupled Resonant Circuits
29. Transients in RLC Circuits
30. Trnasmission Lines
31. Antennas

ANALOG ELECTRONICS CONCEPTS
1. Components
2. Power Sources
3. DC Biasing
4. Amplifier Fundamentals
5. Advanced Amplifier Concepts
6. Power Amplifier Concepts
7. Oscillation
8. Basic Circuit Familiarization

APPLIED MATH TOPS TAUGHT IN ELECTRONICS



ELECTRICAL-ELECTRONIC ASSEMBLER

DIGITAL TASKS

COMBINATROIAL LOGIC CONCEPTS
1. Binary Math
2. Truth Table
3. Logic Definitions and Equivalence
4. Ladder Diagram
5. Logic Functions
6. Code Conversions
7. DeMorgan's Laws
8. Boolean Algebra
9. Minimization
10. Applications

TIMING-LOGIC CONCEPTS
1. Combinatorial Logic
2. Flip-Flops/Bistable Multivibrator
3. One Shots
4. Schmitt Trigger Circuits
5. Simple Counters
6. Counters with Feedback-Analysis
7. Multiplexing Techniques
8. State Transition Diagrams (STD)
9. Synthesis of the Digital Machine
10. Timing and Clock Design Techniques

COMPUTER SOFTWARE CONCEPTS
1. Basic Software
2. Advanced Software

COMPUTER HARDWARE CONCEPTS
1. Basic Computer Concepts
2. Advanced Computer Concepts

ASSEMBLY, INSPECTION, INSTRUMENTATION, AND TESTING
1. Mechanical Assembly
2. Electronic Asembly
3. Microelectronic Assembly
4. Mechanical Inspection
5. Electrical Inspection
6. Printed Circuit Board Fabrication
7. Electrical Instrumentation: Level 1
8. Electronic Instrumentation: Level 2
9. Testing (Special Equipment Operation)

APPENDIX E

ELECTRONICS INSTRUCTORS REVIEWING MATRICES

Conference Held at Northern Arizona University on Monday, July 30, 1984

Roy Harrington, Electronics Instructor
Deer Valley High School
Glendale, Arizona

Mike Lawrence, Electronics Instructor
Mohave Community College
Bullhead City, Arizona

Ken Thompson, Trades and Industry Supervisor
Arizona Department of Education
Phoenix, Arizona

Jim Hardman, Jr., Reserve Electronics Instructor
Mohave Community College
Bullhead City, Arizona

Ron Moody, Electronics Instructor
Pima County Community College
Tucson, Arizona

Tom McCullough, Trades and Industry Teacher Educator
Arizona Center for Vocational Education
Phoenix, Arizona

Larry Fultz
Paradise Valley High School
Phoenix, Arizona

APPENDIX F

INDUSTRIAL REPRESENTATIVES REVIEWING TASK LISTING

Industrial Representatives Who Reviewed the Matrices

John Crosby, Consultant
Crosby and Associates
Tempe, Arizona

Tom DeShong, Manager of Technical Services
National Semiconductor
Tucson, Arizona

Louis Howitz, Director, Materials and Manufacturing Services
Honeywell Processing Management Systems Division
Phoenix, Arizona

Harry Kuhn
Intel Corporation
Chandler, Arizona

Carol Somers, Human Relations Manager
National Semiconductor
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Ray Waddoups, Chief Electrical Engineer
Motorola
Scottsdale, Arizona

Len Wright, Systems Operation
Honeywell Processing Management Systems Division
Phoenix, Arizona

APPENDIX G

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APPENDIX H

ABOUT THE AUTHORS

Richard Bernstein, Ph.D.
Electrical Engineering
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Dr. Bernstein is currently a Professor of Electrical Engineering and Physics at William Rainey Harper College in Palatine, Illinois. He is currently involved in the development and teaching of digital and microprocessor software and hardware courses at the community college. Prior experiences in teaching and industry focus upon communications and control system applications.

Roger A. Mussell, Ph.D.
Education
The Ohio State University, 1974

Dr. Mussell is a Professor of Electronics at William Rainey Harper College in Palatine, Illinois. He is involved in curriculum design, development, and implementation at the college in the specific areas of Electronics and Computer-Aided Design. Prior experiences in teaching and industry focus upon industrial training methods.